

# Chapter 19

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## Ionic Compounds

# IONS

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- **IONS** are atoms or groups of atoms with a positive or negative charge.
- Taking away an electron from an atom gives a **CATION** with a **positive charge**
- Adding an electron to an atom gives an **ANION** with a **negative charge**.
- To tell the difference between an atom and an ion, look to see if there is a charge in the superscript! Examples:  $\text{Na}^+$   $\text{Ca}^{+2}$   $\text{I}^-$   $\text{O}^{-2}$

# Forming Cations & Anions

A CATION forms  
when an atom loses  
one or more  
electrons.

Cation



Mg 12 protons, 12 electrons



An ANION forms  
when an atom  
gains one or more  
electrons

Anion



F 9 protons, 9 electrons



# Charges on Common Ions

1A	2A	3B	4B	5B	6B	7B	8B	1B	2B	3A	4A	5A	6A	7A	8A
H														H	
Li											C	N	O	F	
Na	Mg									Al		P	S	Cl	
K	Ca												Se	Br	
Rb	Sr												Te	I	
Cs	Ba														

By losing or gaining e<sup>-</sup>, atom has same number of e<sup>-</sup>'s as nearest Group 8A atom.

# PREDICTING ION CHARGES

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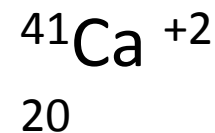
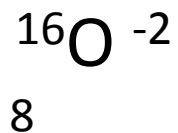
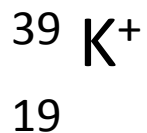
In general

- **metals** (Mg) lose electrons ---> **cations**
- **nonmetals** (F) gain electrons ---> **anions**



## Learning Check – Counting

State the number of protons, neutrons, and electrons in each of these ions.



#p<sup>+</sup> \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

#n<sup>0</sup> \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

#e<sup>-</sup> \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_



## Learning Check – Question 2

Does it get easier or harder to remove an electron from the other shell? Explain.

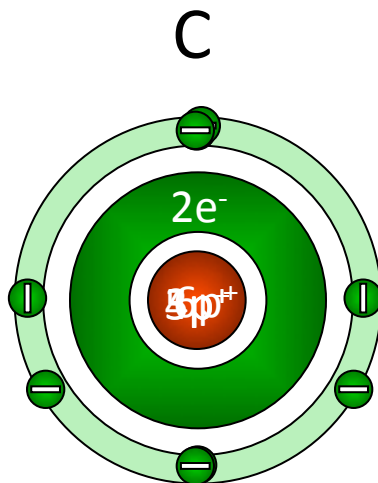
# Shielding effect

- The shielding effect describes the decrease in attraction between an electron and the nucleus in any atom with more than one electron shell.
- Inner electrons tend to shield the outer electrons from the attractive force of the nucleus.
- As you go down group one shielding effect increases.

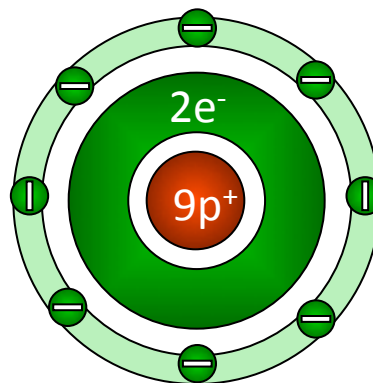
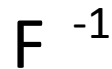
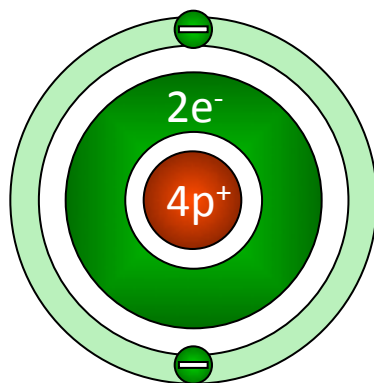
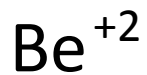
Naming compounds by taking a metal from groups 1A, 1B, or 1C, and combining with a non-metal.

+1 IA																-1 VIIA		0 VIIIA	
1 H	+2 IIA											+3 IIIA	+4 IVA	-3 VA	-2 VIA	1 H	2 He		
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne		
11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar		
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr		
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe		
55 Cs	56 Ba	57 La	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn		
87 Fr	88 Ra	89 Ac	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110	111	112		114		116		118		

How do you know the charge?

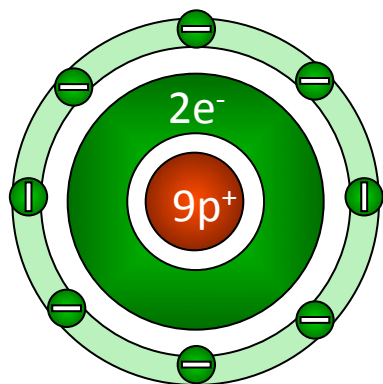
[illegible]

										+1								+4		-1		0	
										IA								VIIA		VIIIA			
										1								1		2			
										H								H		He			
										3								5		6			
										Li								B		C			
										4								7		8			
										Be								N		O			
										11								13		14			
										Na								Al		Si			
										12								15		16			
										Mg								P		S			
										19								31		32			
										K								Ga		Ge			
										20								33		34			
										Ca								As		Se			
										21								35		36			
										Sc								Br		Kr			
										22								49		50			
										Ti								In		Sn			
										23								51		52			
										V								Sb		Te			
										24								81		82			
										Cr								Tl		Pb			
										25								83		84			
										Mn								Bi		Po			
										26								85		86			
										Fe								At		Rn			
										27								114		116			
										Co													
										28								112		114			
										Ni													
										29													
										Cu													
										30													
										Zn													
										37													
										Rb													
										38													
										Sr													
										39													
										Y													
										40													
										Zr													
										41													
										Nb													
										42													
										Mo													
										43													
										Tc													
										44													
										Ru													
										45													
										Rh													
										46													
										Pd													
										47													
										Ag													
										48													
										Cd													
										55													
										Cs													
										56													
										Ba													
										57													
										La													
										72													
										Hf													
										73													
										Ta													
										74													
										W													
										75													
										Re													
										76													
										Os													
										77													
										Ir													
										78													
										Pt													
										79													
										Au													
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										Pb													
										83													
										Bi													
										84													
										Po													
										85													
										At													
										86													
										Rn													
										87													
										Fr													
										88													
										Ra													
										89													
										Ac													
										104													
										Rf													
										105													
										Db													
										106													
										Sg													
										107													
										Bh													
										108													
										Hs													
										109													
										Mt													
										110													
										111													
										112													

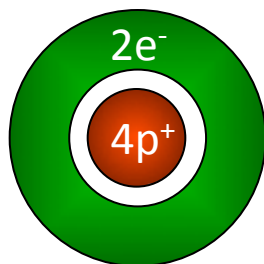


+1												+4				-1		0	
IA														VIIA		VIIIA			
1	+2											+3	-4	-3	-2	1	2		
H	IIA											IIIA	IVA	VA	VIA	H	He		
3	4											5	6	7	8	9	10		
Li	Be											B	C	N	O	F	Ne		
11	12											13	14	15	16	17	18		
Na	Mg											Al	Si	P	S	Cl	Ar		
19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36		
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr		
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54		
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe		
55	56	57	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86		
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn		
87	88	89	104	105	106	107	108	109	110	111	112		114		116		118		
Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt											

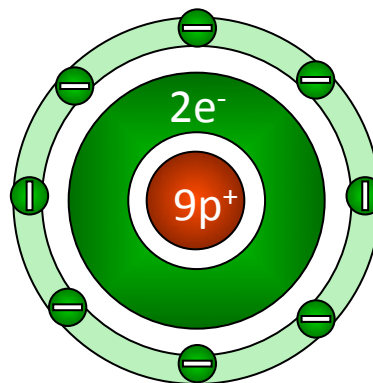
F<sup>-1</sup>



Be<sup>+2</sup>



F<sup>-1</sup>



+1

IA

+2

IIA

+3

IIIA

+4

IVA

-3

VA

-2

VIA

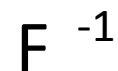
-1

VIIA

0

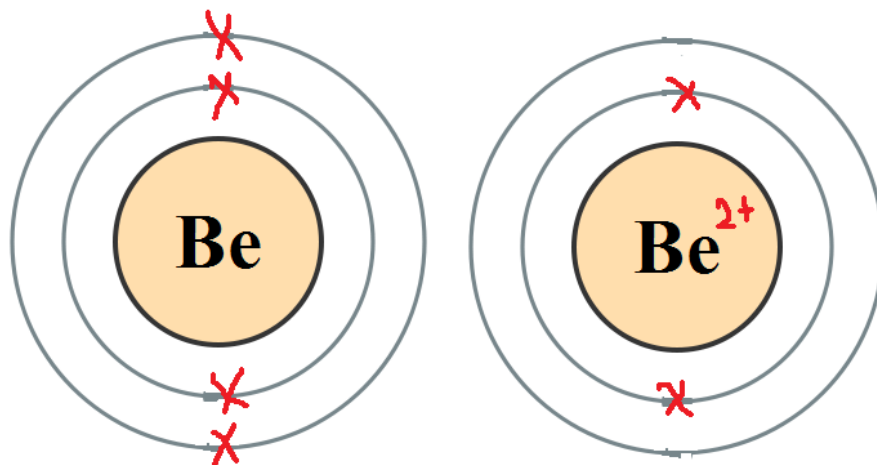
VIIIA

1 H	2 He											3 Li	4 Be	5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar		
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr		
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe		
55 Cs	56 Ba	57 La	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn		
87 Fr	88 Ra	89 Ac	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110	111	112		114		116		118		

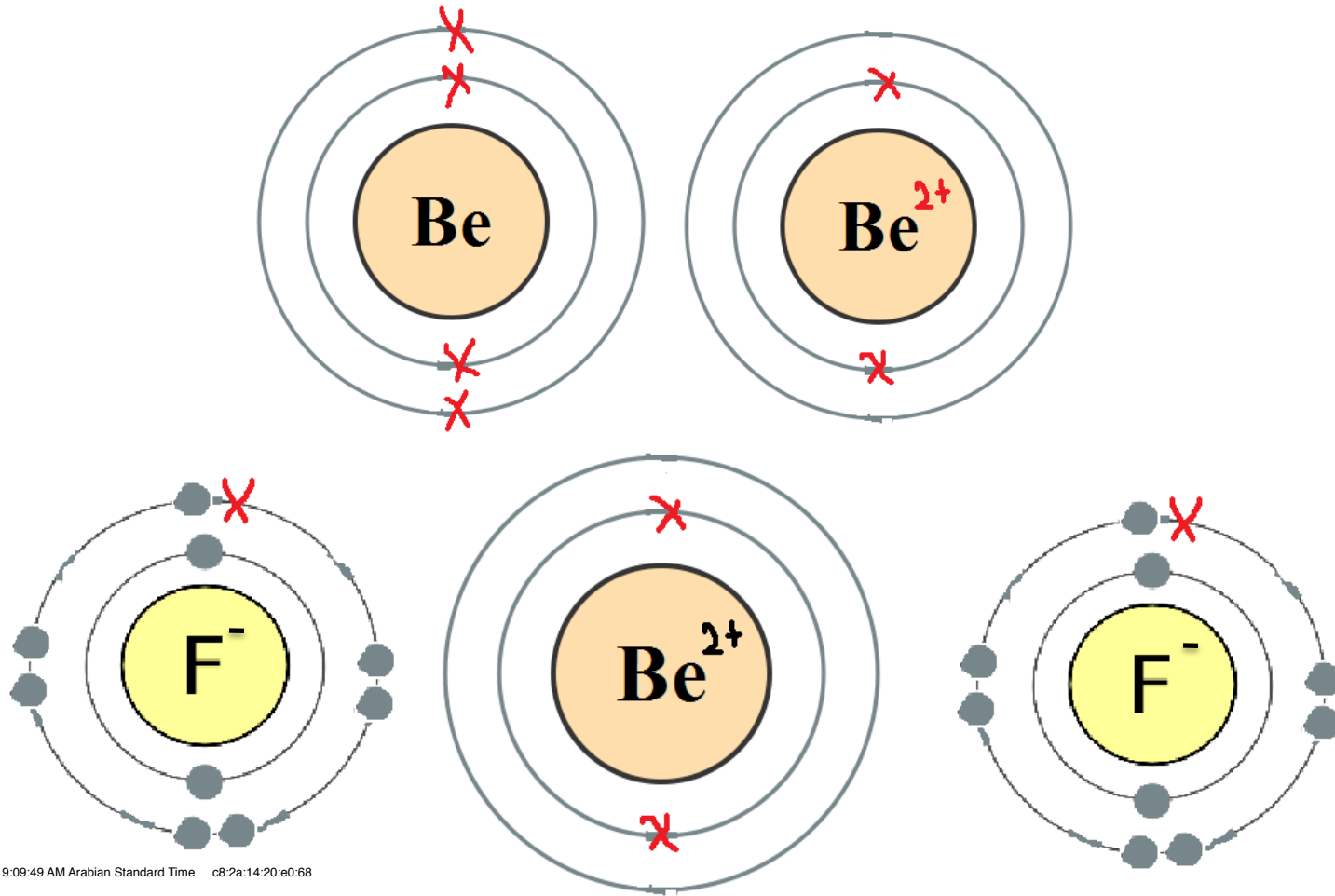

$$\text{BeF}_2$$

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# Dot and Cross Structure



# Dot and Cross Structure



For ionic compounds with a metal from group 1A, 2A, & 3A place the metal first and name it first. The non-metal is put last and named last. The number of metals or non-metals depends on how many it takes to balance the charges.

# METAL

# NON-METAL +ide

+1		METAL										+ide				-1	
IA																VIIA VIIIA	
1	+2											-3	-2	1	2		
H	IIA											IIIA	IVA	VA	VIA	H	He
3	4											5	6	7	8	9	10
Li	Be											B	C	N	O	F	Ne
11	12											13	14	15	16	17	18
Na	Mg											Al	Si	P	S	Cl	Ar
19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
55	56	57	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
87	88	89	104	105	106	107	108	109	110	111	112		114		116		118
Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt									

# Naming Ionic Compounds

- If the ionic compound is binary it will end in "-ide".
- If the negative ion is a polyatomic ion the compound is no longer binary. The ending will be that carried by the polyatomic ion. These endings are either "-ate" or "-ite."

# POLYATOMIC IONS

## Ions with -1 charge

perbromate	$\text{BrO}_4^{-1}$
bromate	$\text{BrO}_3^{-1}$
bromite	$\text{BrO}_2^{-1}$
hypobromite	$\text{BrO}^{-1}$
perchlorate	$\text{ClO}_4^{-1}$
chlorate	$\text{ClO}_3^{-1}$
chlorite	$\text{ClO}_2^{-1}$
hypochlorite	$\text{ClO}^{-1}$
periodate	$\text{IO}_4^{-1}$
iodate	$\text{IO}_3^{-1}$
iodite	$\text{IO}_2^{-1}$
hypoiodite	$\text{IO}^{-1}$

nitrate	$\text{NO}_3^{-1}$
nitrite	$\text{NO}_2^{-1}$
hydroxide	$\text{OH}^{-1}$
cyanide	$\text{CN}^{-1}$
thiocyanate	$\text{SCN}^{-1}$
acetate	$\text{C}_2\text{H}_3\text{O}_2^{-1}$
Permanganate	$\text{MnO}_4^{-1}$
bicarbonate	$\text{HCO}_3^{-1}$

## Ions with a -2 Charge

carbonate	$\text{CO}_3^{-2}$
phthalate	$\text{C}_8\text{H}_4\text{O}_4^{-2}$
sulfate	$\text{SO}_4^{-2}$

sulfite	$\text{SO}_3^{-2}$
chromate	$\text{CrO}_4^{-2}$
dichromate	$\text{Cr}_2\text{O}_7^{-2}$
oxalate	$\text{C}_2\text{O}_4^{-2}$
peroxide	$\text{O}_2^{-2}$

## Ions with a -3 Charge

phosphate	$\text{PO}_4^{-3}$
phosphite	$\text{PO}_3^{-3}$
arsenate	$\text{AsO}_4^{-3}$

## Ions with +1 charge

ammonium ion	$\text{NH}_4^{+1}$
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These polyatomic ions match the charge of the single element

**-1**

Ions with -1 charge

perbromate	$\text{BrO}_4^{-1}$
bromate	$\text{BrO}_3^{-1}$
bromite	$\text{BrO}_2^{-1}$
hypobromite	$\text{BrO}^{-1}$
perchlorate	$\text{ClO}_4^{-1}$
chlorate	$\text{ClO}_3^{-1}$
chlorite	$\text{ClO}_2^{-1}$
hypochlorite	$\text{ClO}^{-1}$
periodate	$\text{IO}_4^{-1}$
iodate	$\text{IO}_3^{-1}$
iodite	$\text{IO}_2^{-1}$
hypoiodite	$\text{IO}^{-1}$

1A	2A		
H			
Li	Be		
Na	Mg		
K	Ca	Sc	Ti
Rb	Sr	Y	Zr
Ce	Ba	La	Hf
Fr	Ra	Ac	Rf

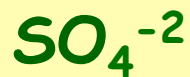
Ce	Pr	Nd	Pm								Tm	Yb	Lu
Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

	3A	4A	5A	6A	7A	8A
	B	C	N	O	F	Ne
	Al	Si	P	S	Cl	Ar
Zn	Ga	Ge	As	Se	Br	Kr
Cd	In	Sn	Sb	Te	I	Xe
Hg	Tl	Pb	Bi	Po	At	Rn

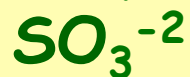
These polyatomic ions match the charge of the single element

### Ions with a -2 Charge

sulfate

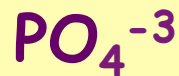


sulfite



### Ions with a -3 Charge

phosphate



phosphite

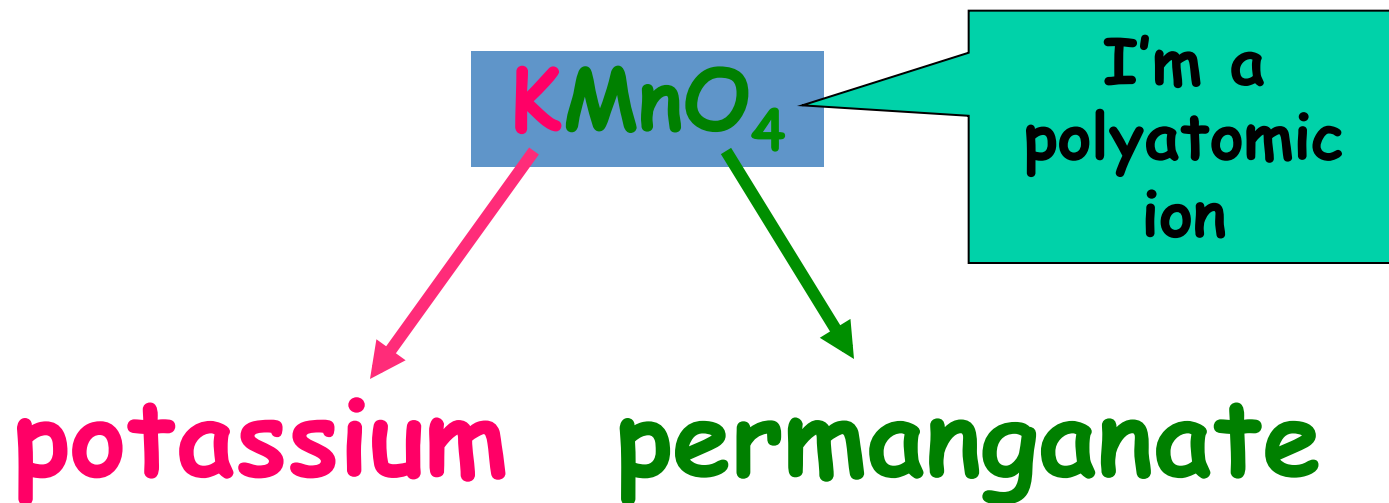


1A	2A	3A	4A	5A	6A	7A	8A
H	He						
Li	Be	B	C	N	O	F	Ne
Na	Mg	Al	Si	P	S	Cl	Ar
K	Ca	Ga	Ge	As	Se	Br	Kr
Rb	Sr	In	Sn	Sb	Te	I	Xe
Ce	Ba	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac	Rf	Db	Sg	Rh	Hs

Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

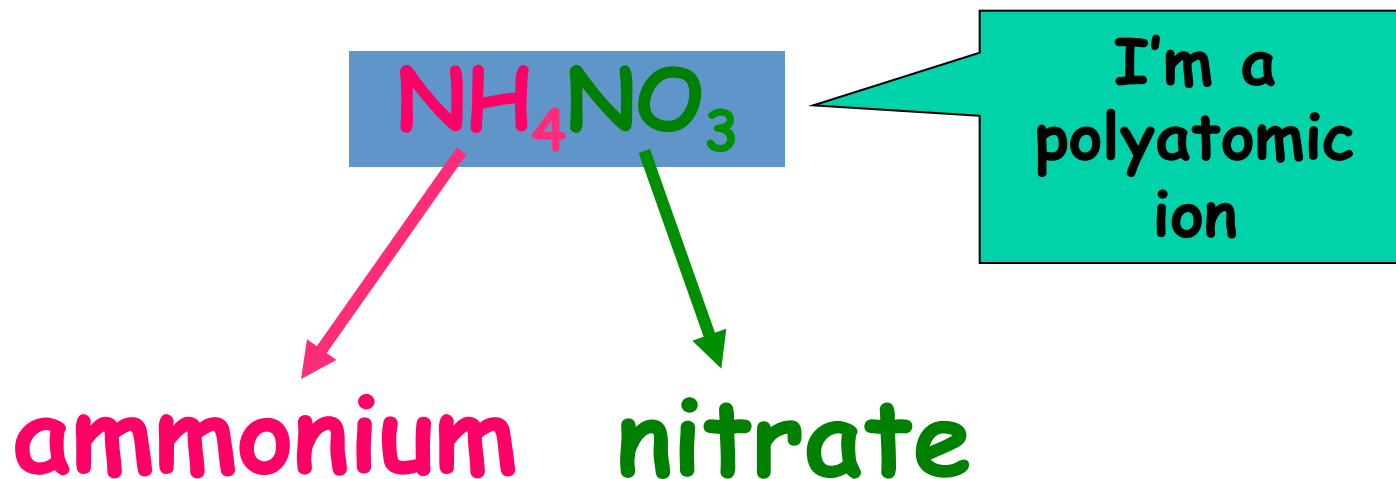
# Examples #1- Formulas to Names

1. Write the names of the ions



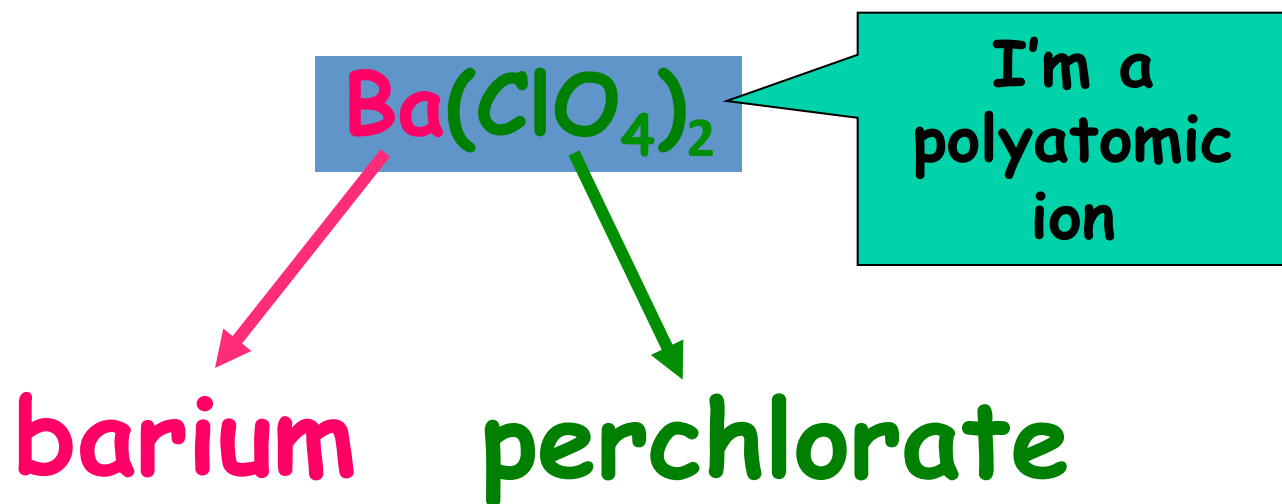
# Examples #2- Formulas to Names

1. Write the names of the ions



# Examples #3- Formulas to Names

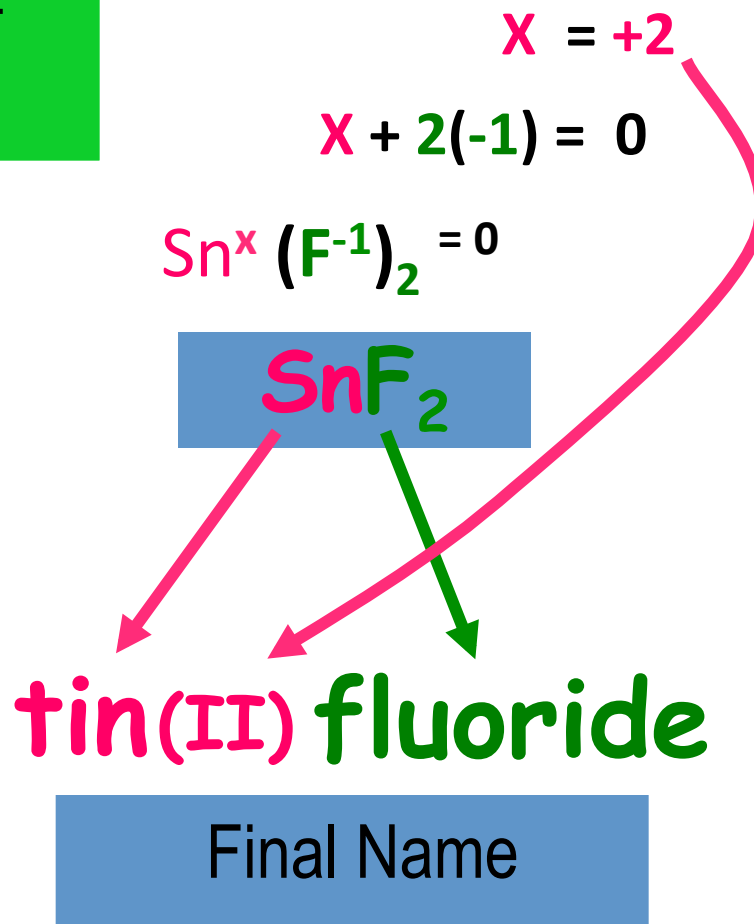
1. Write the names of the ions



# Examples #4- Formulas to Names

1. Write the names of the ions

2. Determine the charge of the positive ion



# Writing Ionic Formulas

- It is easier to write the formula of an ionic compound from its name than the reverse.

# Example #1-Names to Formulas

aluminum chloride

# Example #1-Names to Formulas

1. Write symbols of elements

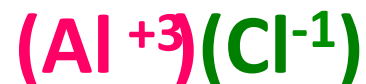
(Al)(Cl)

aluminum chloride

# Example #1-Names to Formulas

1. Write symbols of elements

2. Determine number of ions

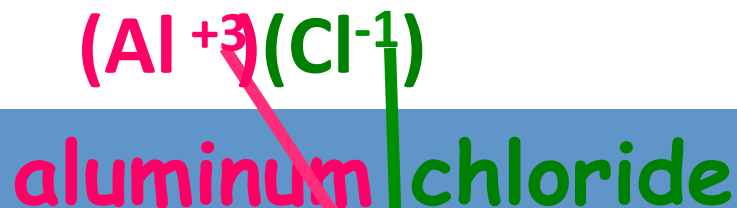


aluminum chloride

# Example #1-Names to Formulas

1. Write symbols of elements

2. Determine number of ions

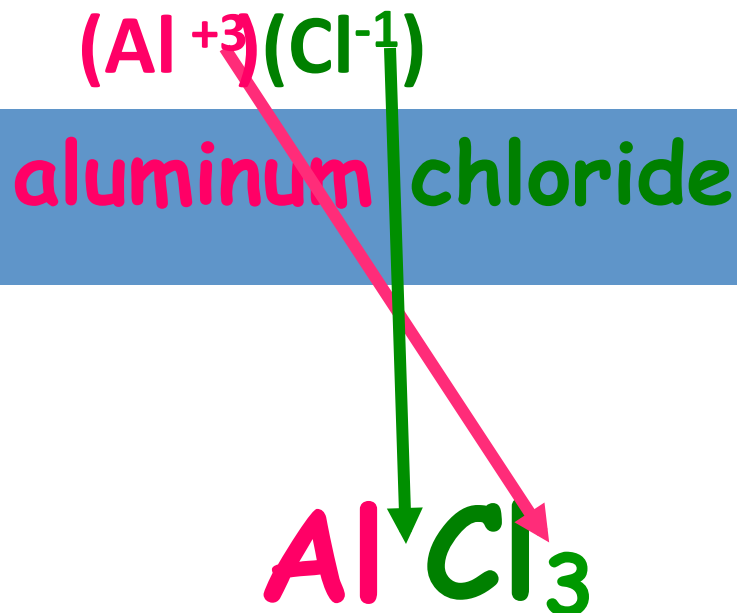


If there is only one atom the  
“1” is not shown

# Example #1-Names to Formulas

1. Write symbols of elements

2. Determine number of ions

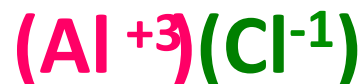


If there is only one atom the  
“1” is not shown

# Example #1-Names to Formulas

1. Write symbols of elements

2. Determine number of ions



aluminum chloride



If there is only one atom the  
“1” is not shown

# Example #2-Names to Formulas

1. Write symbols of elements

2. Determine number of ions

Choose the lowest set of integers that satisfies the equation



lithium phosphate



If there is only one atom the "1" is not shown

# Example #3-Names to Formulas

1. Write symbols of elements

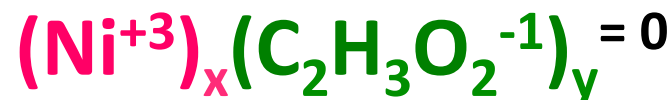
2. Determine number of ions

Choose the lowest set of integers that satisfies the equation

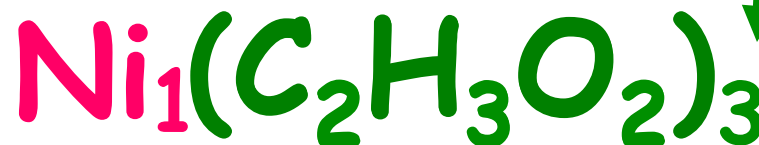
$$\frac{x}{y} = \frac{1}{3}$$

$$3x = 1y$$

$$x(+3) + y(-1) = 0$$



nickel(III) acetate



If there is only one atom the "1" is not shown

Next

# Practice Problems

By now you should have an idea of what is expected when naming covalent binary compounds using prefixes.

In order to master this naming system you need to practice until you feel proficient in naming compounds using prefixes.

# Practice Problem #1



Choose the correct name for the compound

1. Iron trinitrate

No, you do not use prefixes

2. iron(I) nitrate

No, you have the wrong oxidation number

3. iron(III) nitrite

No, you need to review polyatomic ions

4. iron(III) nitrate

Very good, click arrow to continue

5. none of the above

No, there is a correct answer

[Periodic Chart](#)

[Polyatomic Ions](#)

[next problem](#)

# Practice Problem #2

sodium chlorite

Choose the correct formula for the compound

1. NaCl

No, you need to review prefixes

2. NaClO

No, you need to review prefixes

3. NaClO<sub>2</sub>

Very good, click arrow to continue

4. Na(ClO)<sub>2</sub>

No, you have several errors

5. none of the above

No, there is a correct answer

# POLYATOMIC IONS

## Ions with -1 charge

perbromate	$\text{BrO}_4^{-1}$
bromate	$\text{BrO}_3^{-1}$
bromite	$\text{BrO}_2^{-1}$
hypobromite	$\text{BrO}^{-1}$
perchlorate	$\text{ClO}_4^{-1}$
chlorate	$\text{ClO}_3^{-1}$
chlorite	$\text{ClO}_2^{-1}$
hypochlorite	$\text{ClO}^{-1}$
periodate	$\text{IO}_4^{-1}$
iodate	$\text{IO}_3^{-1}$
iodite	$\text{IO}_2^{-1}$
hypoiodite	$\text{IO}^{-1}$

nitrate	$\text{NO}_3^{-1}$
nitrite	$\text{NO}_2^{-1}$
hydroxide	$\text{OH}^{-1}$
cyanide	$\text{CN}^{-1}$
thiocyanate	$\text{SCN}^{-1}$
acetate	$\text{C}_2\text{H}_3\text{O}_2^{-1}$
Permanganate	$\text{MnO}_4^{-1}$
bicarbonate	$\text{HCO}_3^{-1}$

## Ions with a -2 Charge

carbonate	$\text{CO}_3^{-2}$
phthalate	$\text{C}_8\text{H}_4\text{O}_4^{-2}$
sulfate	$\text{SO}_4^{-2}$

sulfite	$\text{SO}_3^{-2}$
chromate	$\text{CrO}_4^{-2}$
dichromate	$\text{Cr}_2\text{O}_7^{-2}$
oxalate	$\text{C}_2\text{O}_4^{-2}$
peroxide	$\text{O}_2^{-2}$

## Ions with a -3 Charge

phosphate	$\text{PO}_4^{-3}$
phosphite	$\text{PO}_3^{-3}$
arsenate	$\text{AsO}_4^{-3}$

## Ions with +1 charge

ammonium ion	$\text{NH}_4^{+1}$
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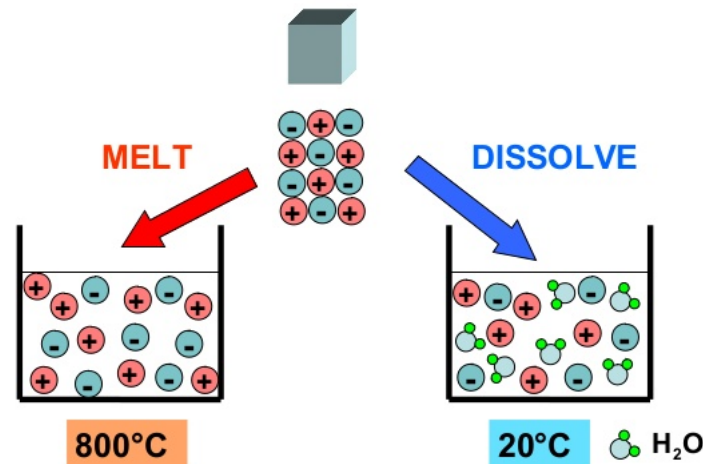
return

# Properties of ionic compounds

## SPLITTING UP IONIC COMPOUNDS 2

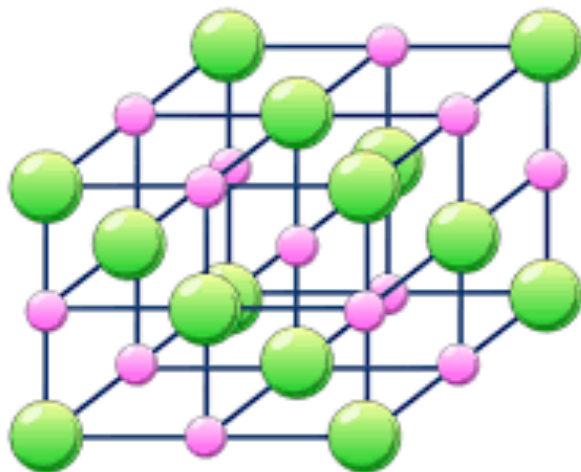
2 ways to split up the ions:

- Ionic compounds:
  - Are made of crystals
  - Have high melting points
  - Are often soluble in water
  - Conduct electricity when molten or dissolved in water
    - When molten or dissolved in water: ions are free to move around.



# Giant ionic structure

- Ions form giant ionic structures called lattice
- Millions of positive and negative ions attracted to each other in fixed positions



KEY

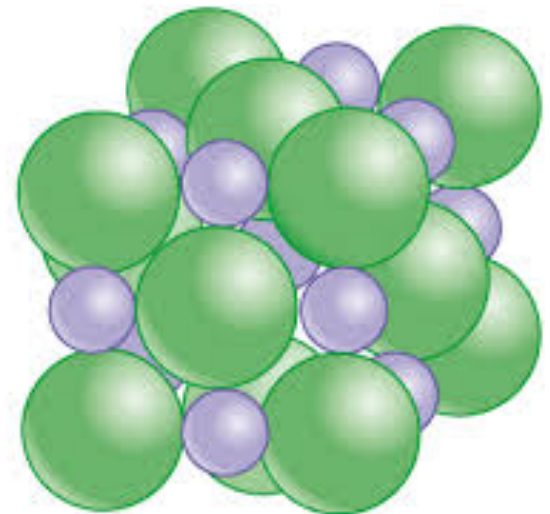
■ Sodium ions  
■ Chloride ions



$\text{Cl}^-$  ion

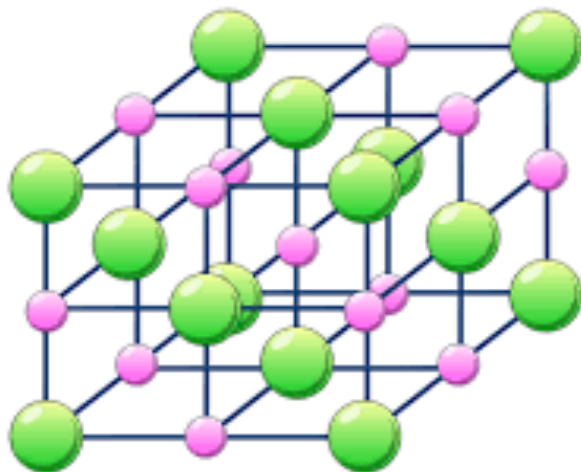


$\text{Na}^+$  ion



# Giant ionic structure

- High melting point: Because of these attractive forces and strong ionic bonding



KEY

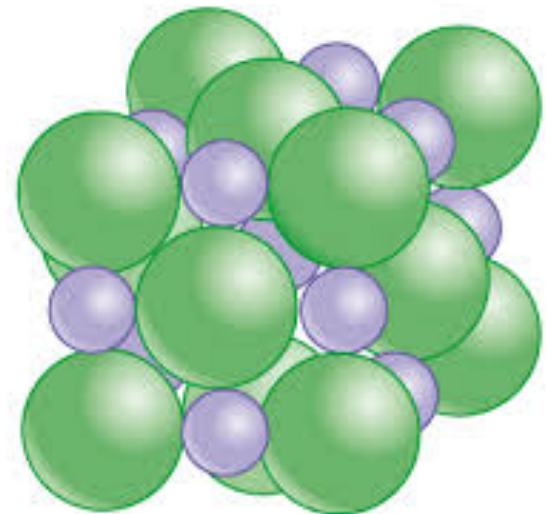
■ Sodium ions  
■ Chloride ions



$\text{Cl}^-$  ion



$\text{Na}^+$  ion



# Giant ionic structure

- Soluble in water (sometimes): because of the attraction of these charges to water which has a slightly negative and positive ends

